AIR, OCEAN AND CLIMATE MONITORING ENHANCING UNDERGRADUATE TRAINING IN THE PHYSICAL, ENVIRONMENTAL AND COMPUTER SCIENCES

W. W. Hope, L. P. Johnson, W. Obi, A. Stewart, W. C. Harris and R. D. Craig
Department of Physical, Environmental and Computer Sciences, Medgar Evers College of the City University of New York

ABSTRACT

Faculty in the Department of Physical, Environmental and Computer Sciences strongly believe in the concept that undergraduate research and research-related activities must be integrated into the fabric of our undergraduate Science and Technology curricula. High level skills, such as problem solving, reasoning, collaboration and the ability to engage in research, are learned for advanced study in graduate school or for competing for well paying positions in the scientific community. One goal of our academic programs is to have a pipeline of research activities from high school to four year college, to graduate school, based on the GISS Institute on Climate and Planets model.

- An information infrastructure has been developed in the Advanced Computing Research Laboratory.

- A new Bachelor of Science degree program in Environmental Science has inspired changes in the approach to teaching Quantitative Analysis and Environmental Measurements and Instrumentation. Project-based activities are incorporated into the laboratory section of these courses.

- Students pursuing degrees in Computer Science, Physical Science and Environmental Science, are encouraged to enroll in Independent Research early in their academic careers. Research Projects include; Ocean Modeling, Remote Sensing, Aerosol Optical Depth, and Meteorological.

A. INTRODUCTION

The Department of Physical, Environmental and Computer Science (PECS) is integrating research and research-related activities into the fabric of undergraduate Science and Technology curriculum. Research provide those high level skills, such as problem solving, data analysis, reasoning, collaboration and appropriate work ethics, that students will need for advanced study in graduate school or for competing for well paying positions in the scientific community. It also makes them better teachers.

A strong relationship with NASA Goddard Institute for Space Studies (GISS) has provided opportunities for students to have hands-on experience in Air, Ocean and Climate studies. An information infrastructure for PECS has been developed, centered at the Advanced Computing Research Laboratory (ACRL), to provide access to NASA GISS facilities and resources from our home campus. This access is contributing to the enhancement of teaching and learning in our class room.

MEC offers both associate and baccalaureate degree programs. The three goals of our academic program are:

a) to have a pipeline of research activities from high school to pre-college, to four year college, to graduate school which is based on the GISS Institute on Climate and Planets (ICP) model;

b) to integrate research and research related activities into the fabric of our undergraduate degree programs as part of the restructuring of Science, Mathematics, Engineering and Technology (SMET) education; and

c) to increase the number of under-represented students in the SMET pipeline who will either further their studies and research in graduate school, research institutions or industry or enter teaching.

Our degree programs are:

- The Bachelor of Science (BS.) Degree Program in Environmental Science focuses on the urban environment and include topics dealing with ethics, responsibility, law and business. Areas of study include: Toxic Sites, Waste Disposal and Management, Air and Water Pollution, Global Warming and Ocean and Atmospheric Studies. Students are required to complete a research project or participate in an internship during their senior year.

- The Associate of Science (A.S.) Degree in Computer Science is concerned with computers, their organization, the theory which underlies their existence, and their application; the program lays the foundation for advanced computing and provides opportunity for hands-on experience. The program follows the guidelines of the ACM and the Computer Society of The IEEE Joint Curriculum Task Force.

- The Associate of Science (A.S.) Degree in Physical Science is essentially a transfer program and has three options: Chemistry, Physics and Engineering. A.S. degree students are encouraged to enroll in Independent Research during their sophomore year.

B. CURRICULUM DEVELOPMENT

The NASA Earth Science enterprise has an educational component; its emphasis is the integration of research into curricula, and this is the primary motivation for modifying old courses, developing new ones and creating new options for our Environmental Science program. A new degree program in Earth Systems Science is also in the developmental stage. New Courses include: Atmospheric Science (Meteorology), Special Topics in Climate and Planets, Remote Sensing - Computer Methods for Satellite Data Analysis, Hydrology (cross listed between Medgar Evers College and the City College of New York), Oceanography, Dynamic Earth (Geology), Internet and Web Technologies and Astrophysics.

University Physics I, II and III, Quantitative Analysis, Environmental Measurement and Instrumentation are modified to include up-to-date information and technology. For example, a Sunphotometer, multi-filter rotating shadowband radiometer, placed on the roof the Science Building, will be used for optical depth measurements, effective particle size and aerosol size distribution, and experiments are being developed for use in University Physics II & III.

New approaches in the teaching of analytical chemistry have been developed; project-based activities are incorporated into the laboratory section of Quantitative Analysis and Environmental Measurements and Instrumentation. Students are required to analyze ambient air for volatile organic compounds and particulate matter.

The proposed Baccalaureate Degree Program in Earth Systems Science will prepare students to become highly skilled in theoretical and applied research in the areas of study in the NASA Earth Science Enterprise. Through the use of NASA data from satellites, all the components of the Earth System: air, water, land, biota and their interaction will be studied. Student will be required to begin a research project during their junior year and complete a senior thesis.

C. INFORMATION INFRASTRUCTURE AND COMPUTER FACILITIES

An information infrastructure for the Department of Physical Sciences and Computer Science has been developed. The local Area Network is designed for easy expansion and a student team under the supervision of the computer science faculty and an external consultant (NEED TITLE FOR DON), assembled the LAN and is currently assisting in network administration activities on a continual bases and is providing technical assistance/support. The network is connected via a Hub concentrator going through the Sun Ultra 1 Server, through a "CISCO" Router, through a "Timplex" Multiplexer with a T1 line to the CUNY Internet Server. Advanced Computing Research Laboratory (ACRL) is the core of the LAN and includes 4 Sun Ultra 1's, Netra J Web Server, Power Macintosh, PC, color laser printer, laser printer, scanner, 4 mm and 8 mm tape drives; software includes the Solaris Operating System (2.5.1), the network file system, a full repertoire of compilers, mathematics software (MathLab, Maple) and image processing (IDL, MIRA Pro). Student also networked 6 faculty offices for 12 faculty, Environmental Science Laboratory, the AMP Learning Center for science students.

Freshman and sophomore students in the new course, Internet and Web Technologies, are obtaining hands-on experience for the development of web pages. For their class projects, students are finalizing our Departmental web site and are making their own web pages. Four teams are responsible for a major component of the PECS site. For their research project, a team of computer science majors are developing a database management system for the Department. Activities completed include:

- Network client/server configuration of Oracle 8.0.5;
- Server configuration implemented on the Sun Solaris 2.5.1 operating system;
- Clients configured in the Windows NT 98 and 95 operating systems; and
- User accounts and user profiles created for computer science courses.

D. UNDERGRADUATE RESEARCH PROGRAM

Students pursuing degrees in Environmental Science, Computer Science and Physical Science transfer are encouraged to enroll in independent research early their academic career. Most of the research projects are located in PECS. A state of the arts Environmental Science Laboratory, The Analytical Chemistry Laboratory and Advanced Computing Research Laboratory are the main facilities. Equipment include: Rotating Shadowband Radiometer, Gas Chromatography (GC), High Performance Liquid Chromatography (HPLC), Gas Chromatography/Mass Spectrometer (GC/MS), Fourier Transform Infra-red Spectrophotometer (FTIR), UV-Visible Spectrophotometer, Atomic Absorption Spectrophotometer, Total Organic Carbon Unit, Mercury Vapor Analyzer, Non-viable Ambient Particle Sizing Sampler (8 Stage), Portable Indoor Air Quality Monitor, Universal Personal Samplers Our faculty and students also have access to other special facilities, such as the Physics (EPR and NMR) Laboratory of Hunter College, the Remote Sensing Laboratory of the City College of New York and the Astrophysical Observatory of the College of Staten Island. Over two dozen Students have given Presentations at National and Local Conferences. Activities for independent research include the follow:

- Atmospheric Remote Sensing: Multifilter Rotating Shadow-band Radiometer
- Studies on Indoor and Ambient Airborne Particles in the New York City Environment.
- Ocean and General Circulation Model (OGCM) Studies of Turbulent Mixing Mechanisms and the Significance of Ocean Turbulence on Global Climate
- Determination of Trihalomethanes in Drinking Water by Micro Liquid-Liquid Extraction and Gas Chromatography
- Indoor Measurements of Elemental Mercury and Lead

- Water Purification System: A Bench-top Model
- Synthesis of Organotin Compounds
- Artificial Intelligence and Knowledge Representation
- Network Configuration of Object Relational Database Management System
- Studies of H II regions of M8, the Lagoon Nebula (South Carolina State University)
- Studying Hurricanes Using Data from Quick Scat and TRMM (City College of NY)
- Magnetic Resonance Studies of Materials for Advanced Batteries and Fuel Cells (Hunter College)
- Photometry of Binary and Variable Stars (College of Staten Island - Astrophysical Observatory)
- Maximum and Minimum Temperature Frequency as a Primary Measure of Global Change (GISS)

E. EXAMPLES OF STUDENT RESULTS

Air Monitoring in the Neighborhood Environment

For laboratory projects and or research, students monitor ambient and indoor air in their neighborhoods. The focus of these activities is determined by current issues and neighborhood concerns. For example, when concern was raised about the use of mercury in religious practices by a segment of the inner-city population, a related project was, "In Search of Mercury in the Brooklyn Environment". The students compared the mercury levels in the homes of suspected users of mercury, with the levels in the home of non-users. Students' results from one such study for a small group-project, indicated that the mercury levels were all below the OSHA limit. However, the level in the home of the suspected user, was twice that of the non-user. The following questions were raise during discussions on the results:

- Is the concern about the religious use of mercury unjustified, since levels in the homes of user and non-user are all below OSHA limit?

- Does the elevated level in the home of the suspected user of mercury present any health risk?

Sometimes, unexpected teaching/learning opportunities are presented as students involve themselves in their project. From one study on "Aldehydes and Ketones in Printing and Photocopying Rooms", as expected, formaldehyde, acetone, acetaldehyde, and benzaldehyde were identified and found to be below the OSHA limit. What captured the students' interest however, was the fact that the two sampling trains which were running simultaneously at two different locations in the same room, produced markedly different results; a significant amount of an unidentified compound (unknown peak at 5.76 min., from chromatogram) was found in sampling position 2 while no such compound was found in sampling position 1. This result encouraged students to have a closer look at the different types of chemicals used in printing and examined the way the chemical were handled and stored in room under investigation.

Air-Borne Particulate Matter a Focus of an Instrumentation Course

Particulate matter (PM) constitute complex a mixtures of air-borne pollutants. They are emitted from natural and anthropogenic sources. Anthropogenic sources are mainly through fossil fuel burning by electrical utilities, industries and motor vehicles. In the urban atmosphere, concentration of particles are more than 50% greater than that for rural or so called clean suburban atmosphere. Inhalation of fine particles (PM10), has shown to worsen asthma and increase bronchial hyperactivity. A large portion of outdoor aerosols penetrate indoor and are trapped, causing indoor air pollution levels to be greater than outdoor. Global and regional climatic conditions are also affected by atmospheric aerosols. Particles in the troposphere scatter solar radiation, trap greenhouse thermal radiation, alter the amount of light

reflected by the earth, and increase the stability and brightness of the clouds. In addition, atmospheric aerosols also contribute to acid rains, and visibility impairment.

Students used a number of analytical equipment to conduct various analyses on particulate matter collected from ambient and indoor air; air-borne particles were analyzed for lead by flame AAS, pesticide (aldrin) by GC-ECD, volatile organic compounds by GC-MSD, and water extractable nitrite by HPLC. The determination nitrite washed off from air-borne particles, presented an opportunity for the students to discuss extensively, the chemistry of nitrogen dioxide interacting with air-borne particles. The following reaction is well known:

$$2NO_2 + H_2O \text{ --> } HNO_3 + HNO_2\cdot$$

The possibility of nitrogen dioxide reacting with surface water on the particulate was established through the students' investigations and discussions.

To introduce students to remote sensing, the multi-filter shadow band radiometer (MFSBR), a sunphotometer, is studied as an instrument for ground-based remote sensing. The sun photometer which is installed the on the roof of Medgar Evers College, enables students to observe changes in the optical depth of ambient aerosols over Brooklyn.

Establishment of an Oracle Database Management System

Computer Science students are establishing an Oracle Database Management System (ODBMS) for the PECS Department. This database system is an object-oriented relational system. They networked and implemented the Oracle Server to the Local Area Network. Clients were configured in various operating systems and the students perform administrative duties. The students are in an applications development phase, which include importing previously developed database systems (urban environmental research groups) into the Oracle environment, and setting up user accounts and user profiles for the Introduction to Database Management Systems course.

F. CONCLUSION

Faculty in the Department of Physical, Environmental and Computer Sciences strongly believe in the concept that undergraduate research and research related activities must be integrated into the fabric of our undergraduate Science and Technology curricula. Thus far, these activities have excited our students through this hands-on approach, and it has given much confidence that they can become a research scientist. In addition it has allowed faculty to have more interesting classes, applied some the results to their research and created a more meaningful mentor-student relationship for many students. We will be developing modules that involve ocean, climate and remote sensing research and we expect to rely heavily on NASA data and educational products for group projects and research for undergraduates (e.g. ocean modeling, remote sensing, climate change, ocean/atmosphere/land mass interaction).

ACKNOWLEDGMENTS

We wish to acknowledge support from NASA Minority University Space Interdisciplinary Networks (MUSPIN); NASA Partnership Award; NASA MASTAP NASA Partnership in Integration of Research in Education (PAIR); NASA Goddard Institute for Space Studies - Institute on Climate and Planets; NSF NYC Alliance - Louis Stokes Alliance for Minority Participation (LSAMP) in Science, Engineering and Mathematics, NSF Instrumentation and Laboratory Improvement; Brooklyn Borough President's Fund; Environmental Protection Agency (EPA); New York State Graduate Research and

Technology Initiative; City University of New York Collaborative Research Program; and Professional Staff Congress/City University of New York Faculty Research Awards

REFERENCES

1 Wenzel, T. J. "A New Approach to Undergraduate Analytical Chemistry" Anal Chem. 1998, 70, No. 23, 470A.

2 Fitch, A.; Wang, Y.; Mellican, S.; Macha, S.; "Lead Lab: "Teaching Instrumentation with One Analyte" Anal Chem. 1996, 68, No. 23, 727A.

3 U. S. Environmental Protection Agency, "Air quality Criteria for Particulate Matter", Volume I. Research Triangle Park, NC: National Center for Environmental Assessment, Office of Research and Development; sections 1.1 to 2.4 ; report no. EPA/600/P-95/001aF.

4 Kieber, R. J.; Seaton, P. J. ; "Determination of Subnanomolar Concentrations of Nitrite in Natural Waters", Anal. Chem. 1995, 67, 3261-3264.

5 Harrison, L., Michalsky, J. and Berndt, J., “Automated Multi filter Shadow-Band Radiometer: an instrument for optical depth and radiation measurement,” Appl. Opt., 1994, 33, 5118-5125.